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(21)Application number : 07-121659 (71)Applicant : SUMITOMO HEAVY IND LTD

(22)Date of filing : 19.05.1995 (72)Inventor : MIYATAKE TSUTOMU

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(54) POSITION DETECTING METHOD APPLIED TO CLOSE EXPOSURE, WAFER AND EXPOSURE MASK

(57)Abstract:
PURPOSE: To absorb the position detecting error caused by the dispersion of the shape of each edge by providing the edges for scattering incident light in a wafer mark and a mask mark, and observing the edges based on the returning of a part of the scattered light in the direction of the observation optical axis.
CONSTITUTION: Edges for scattering incident light are formed in a wafer mark 13 and a mask mark 14. When light enters into these marks, the incident light hitting the edge is scattered. The incident light hitting the other region undergoes regular reflection. Of the scattered light, which is scattered by the edges of the wafer mark 13 and the mask mark 14, the light entering a lens 22 is converged with the lens 22, and the image is formed on the light receiving wafer of an image detector 21. The image signal received in the image detector 21 is processed in a controller 30, and the relative positions of the wafer mark 13 and the mask mark 14 are detected.

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CLAIMS

[Claim(s)]
[Claim 1] The wafer which has the exposure side in which the wafer mark for alignment which has the edge over which incident light is scattered was formed, The process which arranges the exposure mask with which the mask mark for alignment which has the edge over which incident light is scattered was formed across a gap so that said exposure side may counter said exposure mask, Carry out oblique incidence of the illumination light to said wafer mark and a mask mark, and the scattered light from the edge of a wafer mark and a mask mark is observed. The process which detects the relative position of said wafer and said exposure mask is included. Two or more edges of said wafer mark and edges of a mask mark are arranged along the perpendicular direction to the plane of incidence of said illumination light. The location detection approach including the process at which the process which detects said relative position observes the edge of the wafer mark arranged along a perpendicular direction to the plane of incidence of said illumination light, and a mask mark. [two or more]
[Claim 2] The edge of said wafer mark and the edge of said mask mark are the location detection approach according to claim 1 arranged so that the parallel displacement of one side may be carried out where alignment is completed, and it can put on another side.
[Claim 3] At least three pieces are arranged along a perpendicular direction to the plane of incidence of said illumination light for every said wafer mark and mask mark, and the edge of said wafer mark and the edge of a mask mark are the location detection approach according to claim 1 or 2 the spacing is not uniform.
[Claim 4] The die length of two or more edges of said wafer mark is not uniform to mutual, and it is the location detection approach according to claim 1 to 3 which is not uniform to mutual.
[Claim 5] the optical system in which the process which detects said relative position has an objective lens -- said scattered light -- observing -- the inside of the edge of said wafer mark -- the inside of the edge of at least one and said mask mark -- at least one -- the die length -- the resolution of said objective lens -- the location detection approach according to claim 1 to 4 which is the following.
[Claim 6] The location detection approach according to claim 1 to 5 that two or more edges of said wafer mark and edges of said mask mark are arranged in the parallel direction to the plane of incidence of said illumination light.
[Claim 7] The semi-conductor substrate with which it has the exposure side in which the wafer mark for alignment which has the edge over which incident light is scattered was formed, and two or more said edges are arranged along the perpendicular direction

to the plane of incidence of said incident light.
[Claim 8] The semi-conductor substrate according to claim 7 whose die length of two or more of said edges is not uniform.
[Claim 9] At least three of said edge are arranged along the perpendicular direction to the plane of incidence of said incident light, and it is the semi-conductor substrate according to claim 7 or 8 the spacing is not uniform.
[Claim 10] The semi-conductor substrate according to claim 7 to 9 with which two or more said edges are arranged along the parallel direction to the plane of incidence of said incident light.
[Claim 11] The exposure mask with which the mask mark for alignment which has the edge over which incident light is scattered is formed, and two or more said edges are arranged along the perpendicular direction to the plane of incidence of said incident light.
[Claim 12] The exposure mask according to claim 11 whose die length of two or more of said edges is not uniform.
[Claim 13] At least three of said edge are arranged along the perpendicular direction to the plane of incidence of said incident light, and it is the exposure mask according to claim 11 or 12 the spacing is not uniform.
[Claim 14] The exposure mask according to claim 11 to 13 with which two or more said edges are arranged along the parallel direction to the plane of incidence of said incident light.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the location detection approach of having been suitable for the improvement in a throughput of contiguity exposure, about the location detection approach at the time of alignment.
[0002]
[Description of the Prior Art] In the alignment equipment which combined the lens system and the image-processing system, the perpendicular detecting method and the method [of slanting] detecting method are learned as the alignment approach of of the wafer and mask at the time of alignment. The perpendicular detecting method is the approach of observing an alignment mark from a direction perpendicular to a mask side, and the method [of slanting] detecting method is the approach of observing from across.
[0003] The chromatic-aberration duplex focal method is known as the focus approach used by the perpendicular detecting method. A chromatic-aberration duplex focal method is an approach to which observe the mask mark formed in the mask, and the alignment mark formed in the wafer with the light of different wavelength, and the same flat surface is made it to carry out image formation using chromatic aberration. Since a chromatic-aberration duplex focal method can set up the optical resolution of a lens highly theoretically, it can raise an absolute location detection precision.
[0004] On the other hand, in order to observe an alignment mark from a perpendicular direction, the optical system for observation enters an exposure field. When it exposes as [this], in order for optical system to interrupt exposure light, it is necessary to evacuate optical system from an exposure field at the time of exposure. Since the transit time for making it evacuate is needed, a throughput falls. Moreover, since an alignment mark cannot be observed at the time of exposure, location detection becomes impossible. This causes an alignment precision fall under exposure.
[0005] Since optical system is arranged so that an optical axis may become slanting to a mask side, the method [of slanting] detecting method can be arranged so that exposure light may not be interrupted. For this reason, optical system cannot be evacuated during exposure and an alignment mark can be observed also in exposure. Therefore, the location gap under exposure can be prevented, without reducing a throughput.
[0006]
[Problem(s) to be Solved by the Invention] In order for the method [of slanting]

detecting method to observe and carry out image formation of an alignment mark and the mask mark from the method of slanting, the absolute precision of location detection falls according to a distortion. Moreover, since the optical axis of observation light is not in agreement in the optical axis of the illumination light, the optical axis of the illumination light cannot be arranged on the optical axis and the same axle of observation light. Therefore, an illumination-light shaft becomes easy to shift from an ideal optical axis. If an illumination-light shaft shifts from an ideal optical axis, it will become difficult for an image to change and to perform exact location detection.

[0007] The purpose of this invention is offering the location detection approach highly precise alignment's being performed, without dropping a throughput.

[0008]

[Means for Solving the Problem] The wafer which has the exposure side in which the wafer mark for alignment which has the edge over which incident light is scattered according to one viewpoint of this invention was formed, The process which arranges the exposure mask with which the mask mark for alignment which has the edge over which incident light is scattered was formed across a gap so that said exposure side may counter said exposure mask, Carry out oblique incidence of the illumination light to said wafer mark and a mask mark, and the scattered light from the edge of a wafer mark and a mask mark is observed. The process which detects the relative position of said wafer and said exposure mask is included. Two or more edges of said wafer mark and edges of a mask mark are arranged along the perpendicular direction to the plane of incidence of said illumination light. The location detection approach including the process at which the process which detects said relative position observes the edge of the wafer mark arranged along a perpendicular direction to the plane of incidence of said illumination light and a mask mark is offered. [two or more]

[0009] According to other viewpoints of this invention, the location detection approach that the edge of said wafer mark and the edge of said mask mark are arranged so that the parallel displacement of one side may be carried out where alignment is completed, and it can put on another side is offered.

[0010] According to other viewpoints of this invention, the edge of said wafer mark and at least three edges of a mask mark are arranged along a perpendicular direction to the plane of incidence of said illumination light for every said wafer mark and mask mark, and the location detection approach the spacing is not uniform is offered.

[0011] According to other viewpoints of this invention, the die length of two or more edges of said wafer mark is not uniform to mutual, and the location detection approach which is not uniform to mutual is offered.

[0012] the optical system in which the process which detects said relative position has an objective lens according to other viewpoints of this invention -- said scattered light -- observing -- the inside of the edge of said wafer mark -- the inside of the edge of at least one and said mask mark -- at least one -- the die length -- the resolution of said objective lens -- the location detection approach which is the following is offered.
[0013] According to other viewpoints of this invention, the location detection approach that two or more edges of said wafer mark and edges of said mask mark are arranged in the parallel direction to the plane of incidence of said illumination light is offered.
[0014] According to other viewpoints of this invention, it has the exposure side in which the wafer mark for alignment which has the edge over which incident light is scattered was formed, and the semi-conductor substrate with which two or more said edges are arranged along the perpendicular direction to the plane of incidence of said incident light is offered.
[0015] According to other viewpoints of this invention, the mask mark for alignment which has the edge over which incident light is scattered is formed, and the exposure mask with which two or more said edges are arranged along the perpendicular direction to the plane of incidence of said incident light is offered.
[0016]
[Function] If an illumination-light shaft is set the same axle as an observation optical axis and an optical axis is generally aslant arranged to an exposure side, since the reflected light from a wafer mark and a mask mark will not return in the direction of an observation optical axis to normal, these marks cannot be observed. If the edge which scatters incident light over a wafer mark and a mask mark is prepared, since a part of scattered light will return in the direction of an observation optical axis, this edge can be observed.
[0017] If two or more edges of a wafer mark and a mask mark are arranged in the perpendicular direction to plane of incidence, image formation of two or more edges can be carried out to coincidence. If the image of two or more edges is observed to coincidence and location detection is performed, the location detection error by dispersion in the configuration of each edge in a production process is absorbable.
[0018] In quest of the autocorrelation function of the picture signal of a wafer mark and a mask mark, a relative position is detectable by constituting a wafer mark and a mask mark so that the parallel displacement of the wafer mark may be carried out and it can lay on top of a mask mark.
[0019] If the die length of the edge of a mask mark and the die length of the edge of a wafer mark are made into the ununiformity, the image of an edge which does not

correspond among the edges of a wafer mark and a mask mark in similarity pattern matching will not lap completely. When the image of the edge of a wafer mark and a mask mark laps completely, a peak with a big correlation value is shown, but a correlation value does not become so large even if a part of not corresponding image of an edge laps. Since the ratio of the height of the peak of the correlation value when lapping with the time of lapping completely in part becomes large, it can prevent taking the condition of having lapped in part for the condition of having lapped completely.

[0020] Moreover, the same operation is done so even if it makes the pitch of the edge train of a wafer mark and a mask mark into an ununiformity. the die length of the edge of a wafer mark or a mask mark -- the resolving power of a lens -- when it is made below, the image by the scattered light from this edge is approximated to the point intensity distribution of a lens. moreover, the die length of an edge -- the resolving power of a lens -- the image according that it is above to the scattered light from this edge is approximated to the line image intensity distribution of a lens.

[0021] It is expected that the location detection error factors included in the line image and point which are approximated to line image intensity distribution and point intensity distribution, respectively differ. Therefore, it is thought by performing location detection using two kinds of images, a line image and a point, that location detection can be performed with high precision.

[0022] When two or more edges of a wafer mark and a mask mark are arranged in parallel to the plane of incidence of the illumination light and an edge is observed from illumination-light shaft orientations, a focus suits one of edges among two or more edges. Therefore, even if spacing of a wafer and a mask shifts from target spacing, one of edges can be observed vividly.

[0023]

[Example] Drawing 1 (A) shows the outline sectional view of the location detection equipment used in the example of this invention. Location detection equipment is constituted including a wafer / mask attaching part 10, optical system 20, and a control unit 30.

[0024] The wafer / mask attaching part 10 consists of a wafer maintenance base 15, a mask maintenance base 16, and a drive 17. At the time of alignment, a wafer 11 is held on the top face of the wafer maintenance base 15, and a mask 12 is held on the inferior surface of tongue of the mask maintenance base 16. A wafer 11 and a mask 12 are arranged in parallel so that a fixed gap may be formed between the exposure side of a wafer 11, and a mask 12. The wafer mark 13 for alignment is formed in the exposure side of a wafer 11, and the mask mark 14 for alignment is formed in the inferior surface

of tongue (mask side) of a mask 14. Hereafter, a wafer mark and a mask mark are generically called an alignment mark.

[0025] The edge over which incident light is scattered is formed in the wafer mark 13 and the mask mark 14. If light carries out incidence to these marks, the incident light equivalent to an edge will be scattered about and the incident light which was equivalent to other fields will reflect regularly. Here, specular reflection means that almost all components reflect in the same reflective direction among incident light.

[0026] A drive 17 can move relatively in the wafer maintenance base 15 and the mask maintenance base 16. If the z-axis is taken [from Hidari of drawing] in the direction of a normal of the y-axis and an exposure side toward a front face to a rear face in a x axis and the direction perpendicular to space on the right, the wafer 11 and the mask 12 are movable relatively to the direction of a x axis, the direction of the y-axis, the direction of the z-axis, and the surrounding hand of cut (the direction of theta) of the z-axis.

[0027] Optical system 20 is constituted including image detection equipment 21, a lens 22, a half mirror 23, and the light source 24. Optical system 20 is arranged so that the optical axis 25 may become slanting to an exposure side. The illumination light emitted from the light source 24 is made into the flux of light which reflected by the half mirror 23 and met the optical axis 25, and oblique incidence is carried out to an exposure side through a lens 22. The light source 24 is arranged at the focus by the side of the image of a lens 22, and the illumination light emitted from the light source 24 is collimated with a lens 22, and it becomes the parallel flux of light. In addition, the light source 24 can adjust exposure luminous intensity.

[0028] It converges with a lens 22 and image formation of the light which carries out incidence to a lens 22 among the scattered lights scattered about with the edge of the wafer mark 13 and the mask mark 14 is carried out on light-receiving Men of image detection equipment 21. Thus, lighting by optical system 20 is considered as TERESEN lighting, and the observation optical axis is used as the same optical axis to the illumination-light shaft.

[0029] Image detection equipment 21 carries out photo electric conversion of the image of the wafer mark which carried out image formation to the light-receiving side, and a mask mark, and changes it into a picture signal. A picture signal is inputted into a control unit 30. A control unit 30 processes the picture signal inputted from image detection equipment 21, and detects the relative position of the wafer mark 13 and the mask mark 14. Furthermore, a control signal is sent out to a drive 17 so that the wafer mark 13 and the mask mark 14 may become predetermined relative-position relation. A drive 17 moves the wafer maintenance base 15 or the mask maintenance base 16 based

on this control signal.

[0030] Drawing 1 (B) is the top view showing the relative-position relation between the wafer mark 13 and the mask mark 14. The rectangle pattern with which the neighborhood has been arranged in parallel with a x axis or the y-axis is arranged in the three directions of a x axis, and one mark is constituted. In addition, three or more rectangle patterns may be arranged so that it may mention later. The wafer mark 13 consists of pairs and the mask mark 14 is arranged between the wafer marks 13 of a pair.

[0031] The wafer mark 13 and the mask mark 14 of drawing 1 (A) show the cross section in alternate long and short dash line A1-A1 of drawing 1 (B). The illumination light which carried out incidence to the wafer mark 13 and the mask mark 14 is scattered about with the edge projected toward the optical axis of each rectangle pattern of drawing 1 (B). The light irradiated by fields other than an edge reflects regularly, and does not carry out incidence to a lens 22. Therefore, only the scattered light from an edge is detectable with image detection equipment 21.

[0032] Next, the property of the image by the edge scattered light is explained. The optical intensity distribution I of the image by the incoherent homogeneous light are [0033].

[Equation 1]

It is expressed. Here, O (x y) expresses an integral [in / the intensity distribution of the reflected light from an observation body front face, and PSF (x y), and / in an integral / the surface whole region of an observation body]. [the point intensity distribution (point spread function) of a lens]

[0034] If its attention is paid to one edge of each rectangle pattern of drawing 1 (B), the minute point of reflecting light can think that it arranged in parallel with the y-axis. These reflected light intensity distribution from one minute point are assumed to be delta-function [of Dirac] delta. The intensity distribution of the scattered light from one minute point could actually be approximated to the delta function. In the range in which the eye SOPURA Nazism of a lens is materialized, supposing the edge is prolonged in the direction of the y-axis, O(x y) =delta (x) and Lycium chinense will grow.

[0035] A formula (1) is [0036].

[Equation 2]

It can deform. This I (x) is the line image intensity distribution (line spred function) of a lens, and is [0037].

[Equation 3]

I(x) =LSF (x) -- (3)

It can write. Here, LSF (x) expresses the line image intensity distribution of a lens.

[0038] It is [0039] when the illumination light has a continuous spectrum.

[Equation 4]

It is expressed. Here, lambda expresses an integral [in / in the amount of strike slips of the line image by the chromatic aberration of a lens / as opposed to / as opposed to / in the wavelength of light, and LSFlambda / the line image intensity distribution of wavelength lambda / the light of wavelength lambda in deltaxlambda /, and an integral / a full wave length field].

[0040] It turns out that it becomes observing the line image intensity distribution of a lens, and equivalence to observe the scattered light from [from a formula (4)] an edge. Therefore, the always stabilized image can be obtained, without being influenced by observing the scattered light from an edge by the intensity distribution in Men of the reflected light from an observation body.

[0041] The left figure of drawing 1 (C) shows the configuration of the image which carried out image formation to the light-receiving side of the image detection equipment 21 of drawing 1 (A). If the direction which intersects perpendicularly the direction of an intersection of plane of incidence and light-receiving Men including an observation optical axis with a x axis and the x axis within a light-receiving side is made into the y-axis, the image with one edge will become a straight-line-like configuration parallel to

the y-axis. Therefore, the image of each mark becomes the configuration which the image of the shape of a straight line parallel to the y-axis arranged in the three directions of a x axis.

[0042] Between image 13A of the pair by the edge scattered light of the wafer mark 13, image 14A by the edge scattered light of the mask mark 14 is formed. Moreover, to an exposure side, since it is slanting, an observation optical axis is detected in the location where image 14A of a mask mark differs from image 13A of a wafer mark about the direction of a x axis.

[0043] The right figure of drawing 1 (C) shows the optical intensity distribution of the direction of the y-axis of image 13A of a wafer mark, and image 14A of a mask mark. Distance of the direction of the y-axis of image 13A of y1 and the wafer mark of another side of the distance of the direction of the y-axis of image 13A of one wafer mark and image 14A of a mask mark and image 14A of a mask mark is set to y2. By measuring y1 and y2, the relative-position relation of the direction of the y-axis of the wafer mark 13 and the mask mark 14 in drawing 1 (B) can be known.

[0044] For example, what is necessary is just to move one side relatively to another side among a wafer or a mask to position so that a mask mark may come in the center of the wafer mark of a pair about the direction of the y-axis so that y1 and y2 may become equal. Thus, alignment can be carried out about the direction of the y-axis in drawing 1 (B). Alignment can be carried out about a x axis, the y-axis, and the direction of theta by arranging 3 sets of the marks and optical system for alignment as shown in drawing 1 (A) and (B). In addition, although drawing 1 (A) explained the case where an observation optical axis was the same axle as an illumination-light shaft, it is not necessary to be necessarily the same axle. What is necessary is just the conditions in which specular reflection light does not carry out incidence to the objective lens of observation optical system, but only the scattered light carries out incidence.

[0045] Next, how to measure spacing of an exposure side and a mask side is explained. The object point which is carrying out image formation to the light-receiving side of image detection equipment 21 is on a flat surface perpendicular to an optical axis in the object space of optical system 20. Hereafter, this flat surface is called an "image formation-ed side."

[0046] Although the edge which is on an image formation-ed side among each edge of a wafer mark and a mask mark focuses on light-receiving Men, it ****s out of a focus as the edge which is not on an image formation-ed side does not focus but it keeps away from an image formation-ed side. Therefore, an image fades as the image of the edge which is in the location nearest to an image formation-ed side among the edges of each

mark becomes the clearest and separates from the edge in the direction of a x axis.

[0047] It sets to drawing 1 (C) and is distance x1. The distance of the direction of a x axis of the point of image 13A of a wafer mark and image 14A of a mask mark which is most to the point, respectively is expressed. Namely, distance x1 It is almost equal to the distance of the point which carried out perpendicular projection of the focusing point of a wafer mark, and the focusing point of a mask mark to plane of incidence.

[0048] Drawing 1 (D) shows the sectional view in the plane of incidence near the image formation-ed side of the wafer side 11 and the mask side 12. Point Q2 The point on the intersection of the wafer side 11 and an image formation-ed side, and point Q1 It is a point on the intersection of the mask side 12 and an image formation-ed side. Segment Q1 Q2 Distance [in / in die length / drawing 1 (C)] x1 It corresponds.

[0049] Segment Q1 Q2 When die length is expressed with L (Q1 Q2), the spacing delta of the exposure side 11 and the mask side 12 is [0050].

[Equation 5]

Delta=L (Q1 Q2) xsin (alpha) -- (5)

It is expressed. Here, alpha is an angle of the direction of a normal of the wafer side 11, and an optical axis 25 to make. Therefore, distance x1 in drawing 1 (C) It measures and is segment Q1 Q2. Spacing delta can be known by finding die length. In order to know spacing delta to accuracy more, it is distance x1. Measuring correctly is desirable. For that, the one where the depth of focus of a lens is shallower is good.

[0051] To a control unit 30, it is distance x1 beforehand. Distance x1 which was made to memorize desired value and was measured By controlling a drive 17 to approach desired value, spacing of the wafer side 11 and the mask side 12 can be set as desired spacing.

[0052] Next, the experimental result which observed the scattered light from a wafer mark is explained. Drawing 2 (A) shows the top view of a wafer mark used for the observation experiment. The pattern of three rectangles is arranged in parallel and constitutes one wafer mark. The width of face of a rectangle pattern is 6 micrometers, and die length is 100 micrometers. Each rectangle pattern has the edge over which incident light is scattered. Hereafter, the pattern which has the edge over which incident light is scattered is called an edge pattern like this rectangle pattern.

[0053] Both drawing 2 (B) and drawing 2 (C) show the sectional view in alternate long and short dash line B-2-B-2 of drawing 2 (A). In the wafer shown in drawing 2 (B), the resist pattern 41 (micro POJITTO 2400 made from SHIPURE) is formed on the front face of a silicon substrate 40. The thickness H1 of a resist pattern 41 is 1.2 micrometers, and width of face W is 6 micrometers.

[0054] Distance of the center line of a central edge pattern and the center line of the edge pattern of both sides is set to y3 and y4, respectively. Ten kinds of wafer marks whose y3-y4 are 0nm, 20nm, 40nm, and 60nm ... 180nm are formed in the wafer used for the experiment. Hereafter, y3-y4 are called the amount of displacement of a central edge pattern. In addition, each mark of y3+y4 is 26 micrometers.

[0055] In the wafer shown in drawing 2 (C), the heights 44 of silicon are formed on the front face of a silicon substrate 40. The height H2 of heights 44 is 0.5 micrometers. The laminating of the FOSUFO silicate glass (PSG) film 42 with a thickness of 0.7 micrometers and the resist film 43 with a thickness of 1.45 micrometers is carried out to this sequence so that the front face of a silicon substrate 40 may be covered. The width of face and spacing of heights 44 are the same as that of it which shows drawing 2 (B).

[0056] Drawing 3 (A) shows the image when observing the wafer mark formed with the resist pattern shown in drawing 2 (B) from the method of slanting, as shown in drawing 1 (A). The numerical aperture NA of an objective lens of the microscope used for observation is 0.4 and 100 times the detection scale factor of this. The plane of incidence of an illumination-light shaft is parallel to the longitudinal direction of each edge pattern of drawing 2 (A), the angle with the normal of an exposure side to make is 30 degrees, and it observed by the optical system which has an illumination-light shaft and the observation optical axis of the same axle. In drawing 3 (A), the image corresponding to three wafer marks is observed. The image of the shape of an ellipse located in a line three for every wafer mark has appeared. These are the images by the scattered light from the shorter side of the edge pattern of drawing 2 (A).

[0057] In addition, the image with which the image of the shape of an ellipse located in a line three has appeared caudad among drawing is based on the edge scattered light from the serial number mark formed under each mark. However, it scans in the longitudinal direction of drawing 3 (A) with image detection equipment, and if location detection is performed only based on the picture signal of the scanning line concerning the image of the shape of an ellipse located in a line three, the effect by the downward image is avoidable.

[0058] Drawing 3 (B) shows the image when observing the wafer mark formed with the resist pattern shown in drawing 2 (B) from [of an exposure side] a normal. In drawing 3 (B), the image corresponding to three wafer marks has appeared. The figure mark formed under each mark is a figure which shows the serial number of a wafer mark.

[0059] Drawing 4 shows the part which is equivalent to one wafer mark among the picture signals corresponding to the scanning line concerning the image of the shape of an ellipse of drawing 3 (A). An axis of abscissa expresses the location on an exposure

side, and an axis of ordinate expresses optical reinforcement. The peak of the shape of three rectangle has appeared corresponding to the image of the shape of an ellipse located in a line three. Thus, the picture signal which shows a peak corresponding to an edge part can be acquired by detecting the edge scattered light.

[0060] Although drawing 3 and drawing 4 showed the image and picture signal at the time of observing the wafer mark formed with the resist pattern shown in drawing 2 (B), the same image and the same picture signal were able to be acquired also about the wafer mark which has the laminated structure shown in drawing 2 (C) .

[0061] Drawing 5 carries out signal processing of the picture signal, and shows the result of having measured amount yof displacement3-y4 of a central edge pattern. In the wafer mark formed with the resist pattern shown in drawing 2 (B), drawing 5 (A) is the case of the wafer mark of the laminated structure which shows drawing 5 (B) to drawing 2 (C). An axis of abscissa expresses the serial number of a wafer mark. Here, amount yof displacement3-y4 of the wafer mark of serial number n are nx20nm. An axis of ordinate expresses with Unit nm amount yof displacement3-y4 calculated by observation.

[0062] Notation <> in drawing shows the amount of displacement observed by perpendicular detection, and notation ** shows the amount of displacement observed by the edge scattered light. The amount of displacement observed by the edge scattered light was calculated with similarity pattern matching (the - of 14th line 7th page left upper column of the 3rd line of the 4th page left lower column of JP,2-91502,A).

[0063] Below, the measuring method of the amount of displacement by similarity pattern matching is explained briefly. First, the differential picture signal which differentiated the picture signal shown in drawing 4 is acquired. The autocorrelation function of this differential picture signal is calculated. When the peak of the center of drawing 4 , a left-hand side peak, and a central peak and a right-hand side peak lap, an autocorrelation function shows the maximal value. Therefore, distance y3 and y4 can be found by calculating movement magnitude in case an autocorrelation function takes the maximal value. Thus, amount yof displacement3-y4 are calculated from the found distance y3 and y4.

[0064] In order to ask accuracy for distance y3 and y4 more, when the parallel displacement of the peak of the differential picture signal corresponding to a wafer mark is carried out, considering as the configuration which maintained similarity is desirable so that it may lap with the peak of the differential picture signal corresponding to a mask mark mostly.

[0065] As shown in drawing 5 (A), when a wafer mark is formed with a resist pattern,

amount yof displacement3-y4 which observed and asked for the edge scattered light are almost equal to it for which it asked by the conventional perpendicular detection about all the serial numbers 0-9 of a wafer mark.

[0066] As shown in drawing 5 (B), when a wafer mark was formed by the heights of silicon, amount yof displacement3-y4 which observed and asked for the edge scattered light became a little larger than it for which it asked by the conventional perpendicular detection about all the serial numbers 0-9 of a mark. The increment of the observed amount of displacement was about 13nm. An about 13nm difference is not the amount which becomes a big problem by the alignment in X-ray lithography. Moreover, this difference will become small by considering as the wafer mark configuration where it explains in the example later.

[0067] By the above-mentioned approach, the scattered light from one edge of a wafer mark and a mask mark is performing location detection. By dispersion in a mask production process or a wafer production process, when the edge configuration of each mark shifts from an ideal configuration, exact location detection becomes impossible. Next, the 1st example made into the configuration which cannot be influenced [according the configuration of a wafer mark and a mask mark to dispersion in a production process] easily is explained.

[0068] Drawing 6 (A) shows the top view of the alignment mark by the 1st example of this invention. The system of coordinates which make an exposure side xy flat surface and make the direction of a normal the z-axis are considered. The wafer marks 52A and 52B of a pair are arranged along with the y-axis, and the mask mark 62 is arranged in the meantime. In addition, other examples mentioned later are explained using the same system of coordinates.

[0069] Both the wafer marks 52A and 52B are considered as the configuration by which the pattern (edge pattern) 51 of the shape of a rectangle which has the edge over which incident light is scattered has been arranged in the shape of a grid along with a x axis and the y-axis. Drawing 6 (A) shows the case where five edge patterns 51 are arranged along three pieces and a x axis along with the y-axis. The mask mark 62 is similarly considered as the configuration by which the edge pattern 61 has been arranged in the shape of a grid.

[0070] Drawing 6 (B) shows the sectional view in alternate long and short dash line B6-B6 of drawing 6 (A). The edge pattern 51 is formed on the front face of a wafer 50. The edge pattern 61 is formed in the inferior surface of tongue of a mask 60.

[0071] Drawing 6 (C) shows the sectional view in alternate long and short dash line C6-C6 of drawing 6 (A). The edge pattern 51 of W or 61 is arranged for y-axis lay

length in the pitch P along with the y-axis in each alignment mark. The pitch of y5, wafer mark 52B, and the mask mark 62 is set to y6 for the pitch of wafer mark 52A and the mask mark 62.

[0072] Drawing 6 (D) shows the picture signal at the time of observing the edge scattered light from the alignment mark shown in drawing 6 (A) - (C) from the oblique light shaft included in xz side. An axis of abscissa expresses the location of the direction of the y-axis, and an axis of ordinate expresses signal strength. There are three edge patterns located in a line in the direction of the y-axis in each alignment mark on a perpendicular flat surface to an oblique light shaft. For this reason, three edge patterns located in a line in the direction of the y-axis can be located in a line with coincidence on the image formation-ed side of observation optical system, and each edge scattered light from each edge pattern ties a clear image. Three peaks are observed by the location corresponding to the wafer marks 52A and 52B and the mask mark 62, respectively. The width of face of a peak is equal to y-axis lay length W of an edge pattern, and the pitch of a peak train is equal to the pitch P of the direction of the y-axis of an edge pattern.

[0073] Drawing 6 (E) shows the autocorrelation function of the differential picture signal which differentiated the picture signal shown in drawing 6 (D). An axis of abscissa expresses movement magnitude deltay of the direction of the y-axis, and an axis of ordinate expresses a correlation value. In drawing 6 (D), the parallel displacement of the peak corresponding to wafer mark 52A is carried out to the positive sense of the y-axis. A correlation value becomes large in the place where the peak at the right end of wafer mark 52A lapped with the peak at the left end of the mask mark 62, and as shown in drawing 6 (E), a peak a1 appears.

[0074] If only a pitch P furthermore moves to the positive sense of the y-axis, the right end of wafer mark 52A and a central peak will lap with the center of the mask mark 62, and a left end peak, respectively. Since two peaks of a picture signal have lapped at this time, rather than the time of one peak having lapped, a correlation value becomes large and the peak a2 higher than a peak a1 appears.

[0075] If only a pitch P furthermore moves to the positive sense of the y-axis, three peaks of wafer mark 52A will lap with three peaks of the mask mark 62. At this time, a correlation value becomes max, and the highest peak a3 appears. If it furthermore moves, the peak of the almost same height as peaks a2 and a1 will appear in order. Movement magnitude deltay which gives the highest peak a3 is equivalent to the pitch y5 of wafer mark 52A and the mask mark 62. The pitch y6 of wafer mark 52B and the mask mark 62 can be found similarly.

[0076] Thus, if three edge patterns are arranged in the direction of the y-axis, the edge scattered light from three edge patterns can be observed to coincidence. For this reason, even if the configuration of one edge part shifts from an ideal configuration by dispersion in a production process etc., since the edge scattered light of other edge parts is also observed to coincidence, location detection can be carried out at high degree of accuracy. In addition, the number of the edge patterns arranged along the direction of the y-axis could acquire the same effectiveness by arranging not only three pieces but two patterns or more.

[0077] Drawing 6 (A) When the alignment mark shown in - (C) is used, as shown in drawing 6 (E), the peak a2 with a little low height appears in the both sides of the greatest peak a3. When a peak a2 is taken for the greatest peak, exact location detection becomes impossible. This misconception becomes easy to take place, when the number of the edge patterns arranged along with the y-axis increased, or when the S/N ratio of a picture signal falls. The 2nd example which made the alignment mark hereafter the configuration which misconception of a peak cannot produce easily is explained.

[0078] Drawing 7 (A) shows the sectional view of the alignment mark by the 2nd example. In addition, the plane configuration of an alignment mark is the same as that of the case of the 1st example shown in drawing 6 (A). Each alignment marks 52A, 52B, and 62 are constituted including three edge patterns arranged along with the y-axis. In each alignment mark, the die length of the edge in alignment with the y-axis of an edge pattern is not uniform. When parallel translation of the one alignment mark is carried out along with the y-axis and it lays on top of other alignment marks, each edge pattern is formed so that the die length of the edge of a corresponding edge pattern may become equal.

[0079] The die length of the edge of W2 and the edge pattern of both sides of the die length of the edge of the edge pattern of the center of each alignment mark shown in drawing 7 (A) is W1. The pitch of the direction of the y-axis of an edge pattern is P in each alignment mark. The pitch of y5, wafer mark 52B, and the mask mark 62 of the pitch of wafer mark 52A and the mask mark 62 is y6.

[0080] Drawing 7 (B) shows the picture signal at the time of observing the edge scattered light from the alignment mark shown in drawing 7 (A) from the oblique light shaft within xz side. Three peaks are observed by the location corresponding to the wafer marks 52A and 52B and the mask mark 62, respectively. The width of face of the peak of W2 and both sides is set to W1 by the width of face of the peak of the center of each alignment mark. The pitch of a peak train is equal in the pitch P of the direction of the y-axis of an edge pattern in one alignment mark.

[0081] Drawing 7 (C) shows the autocorrelation function of the differential picture signal which differentiated the picture signal shown in drawing 7 (B). Five peaks have appeared like the case of drawing 6 (E). A peak b1 corresponds, when the peak at the right end of wafer mark 52A and the peak at the left end of the mask mark 62 lap, and the peak b2 corresponds, when the right end of wafer mark 52A and a central peak lap with the center of the mask mark 62, and a left end peak, respectively. The peak b3 corresponds, when three peaks of the mask mark 62 lap with wafer mark 52A, respectively.

[0082] In the condition which shows a peak b2, since the peak width of the signal strength which has lapped mutually differs, compared with the case where peak width is equal, a correlation value is small. For this reason, the height of a peak b2 becomes lower than the height of the peak a2 in drawing 6 (E). Since the ratio of the height of the greatest peak b3 and the peak b2 of the both sides becomes large, it is hard coming to generate misconception of the maximum peak.

[0083] In addition, although drawing 7 (A) showed the case where the die length of the edge of the edge pattern in each alignment mark was made into an ununiformity, the die length of an edge is made into homogeneity, and it is good even if uneven in the pitch of an edge pattern. Moreover, the die length of an edge and the both sides of a pitch may be made into an ununiformity. In addition, in order to control generating of misalignment, it is desirable to make extent of the die length of an edge or the ununiformity of a pitch into **10% or more.

[0084] Next, the 3rd example is explained with reference to drawing 8 and drawing 9 . Drawing 8 (A) shows the perspective view of one edge pattern of a wafer mark. The illumination light is made to be shot slanting ON in accordance with the oblique light shaft within xz flat surface of drawing, and the scattered light from the edge which extends along with the y-axis is observed. In this case, since the image by the scattered light becomes the intensity distribution shown by the above-mentioned formula (4), the image equivalent to the line image intensity distribution of a lens as shown in drawing 8 (B) is obtained.

[0085] As shown in drawing 8 (C), the die length of the edge which extends along with the y-axis is shortened. If the die length of an edge becomes shorter than the resolution of a lens, the intensity distribution O (x y) of the reflected light in a formula (1) will be able to be set with delta (x y). Therefore, a formula (1) is [0086].

[Equation 6]

It can deform. Here, PSF (x y) expresses the point intensity distribution of a lens.
[0087] It is [0088] when the illumination light has a continuous spectrum.
[Equation 7]

It can express. Here, lambda expresses an integral [in / in the amount of strike slips of the point by the chromatic aberration of a lens / as opposed to / as opposed to / in the wavelength of light, and PSFlambda / the point intensity distribution of wavelength lambda / the light of wavelength lambda in deltaxlambda /, and an integral / a full wave length field].
[0089] thus, the die length of an edge -- the resolution of a lens -- the point approximated to the point intensity distribution of a lens as shown in drawing 8 (D) can be acquired by making it below. It is expected that the location detection error factors included in the line image and point which are approximated to line image intensity distribution and point intensity distribution, respectively differ. When it integrates with the image by the edge scattered light in the die-length direction of an edge, it is thought that it does not have big effect on a point although an error factor by which an error component is accumulated affects a line image greatly. Conversely, it is thought that it does not have big effect on a line image although an error factor which an error component negates mutually affects a point greatly.
[0090] It is thought by forming the edge which connects a line image to an alignment mark, and the edge which connects a point that a location detection error becomes small synthetically. Drawing 9 (A) shows the sectional view of the alignment mark by the 3rd example. The wafer marks 52A and 52B are formed on the front face of a wafer 50. The mask mark 62 is formed in the inferior surface of tongue of a mask 60. Each alignment mark is constituted including five edge patterns arranged along with the y-axis. The thing of both ends has the die length of the edge which extends in the direction of y shorter than the resolution of a lens among five edge patterns.

[0091] Drawing 9 (B) shows the picture signal at the time of observing the edge scattered light from the alignment mark of drawing 9 (A) from the oblique light shaft within xz side. Five peaks have appeared, respectively in the location corresponding to the wafer marks 52A and 52B and the mask mark 62. Among five peaks, the peak width of both ends is narrow and can be approximated to the point intensity distribution of a lens. By performing similarity pattern matching using the differential picture signal which differentiated this picture signal, location detection can be performed using both a point and a line image.
[0092] In the above 1st - the 3rd example, the edge pattern has been arranged along the direction of a normal of plane of incidence, and how to reduce a location detection error was explained. Next, an edge pattern is arranged in the direction parallel to plane of incidence, and how to perform location detection without receiving effect in dispersion in spacing of a wafer and a mask is explained.
[0093] Drawing 10 (A) shows the top view of the wafer mark by the 4th example. The 21 rectangles-like edge pattern 70 has arranged in 4-micrometer pitch along a x axis. Three trains of trains of this edge pattern 70 are arranged in the direction of the y-axis.
[0094] Drawing 10 (B) shows the wafer mark in the case of observing the wafer mark of drawing 10 (A) from [of 30 degrees of incident angles included in xz side] an optical axis, and the outline sectional view of optical system. The edge pattern 70 is formed on the front face of a wafer 71. Oblique incidence of the illumination light parallel to the oblique light shaft 73 is carried out, and the scattered light from the edge of the edge pattern 70 is observed. The broken line 72 in drawing expresses the image formation-ed side of observation optical system.
[0095] When a wafer 71 is in the location of u1 of drawing, the 5th edge pattern is located on the image formation-ed side 72 from Hidari of drawing. When the parallel displacement of the wafer 71 is carried out in accordance with an optical axis 73 and a wafer 71 comes to the location of u2 and u3 of drawing, the 3rd left end edge pattern will be located on the image formation-ed side 72 from Hidari of drawing, respectively.
[0096] If 2 micrometers of wafers 71 are moved in the direction of an optical axis when the pitch of the direction of a x axis of the edge pattern 70 is 4 micrometers, one edge pattern located on the image formation-ed side 72 will shift. Therefore, a focus can be doubled with one of edge patterns whenever it sets the depth of focus of a lens to 1 micrometer.
[0097] Drawing 10 (C) is observed by the approach of showing the wafer mark shown in drawing 10 (A) in drawing 10 (B), and the wafer location dependency of the detection location when performing location detection of an edge pattern is shown. An

axis of abscissa expresses the serial number of an edge pattern to the point, and an axis of ordinate expresses a detection value with Unit nm. Here, the detection value was defined as the one half of the mutual difference of spacing of the edge pattern which exists in the center about the direction of the y-axis, and each edge pattern in the both sides.

[0098] The migration length of the direction of an optical axis of a wafer to the condition which is observing the 21st edge pattern from the condition which is observing the 1st edge pattern is 40 micrometers. A detection value is restored to the range of -17nm - +25nm even if it moves 40 micrometers of wafers, as shown in drawing 10 (C).

[0099] Thus, even if it moves a wafer in the direction of an optical axis, the location of an edge pattern can be detected comparatively with high precision. Moreover, it is thought that the main factors of dispersion in a detection value are based on dispersion in the configuration of an edge pattern. Therefore, if two or more edge patterns are arranged in the direction of the y-axis, two or more edge patterns are observed to coincidence and location detection is performed as the 1st example explained, highly precise location detection will be able to be performed.

[0100] Drawing 11 shows the sectional view of the wafer mark which arranged two or more edge patterns in the direction parallel to plane of incidence, and a mask mark. The broken line 72 in drawing shows the image formation-ed side of observation optical system.

[0101] Since one of edge patterns is located on the image formation-ed side 72 when a wafer 71 is in the location expressed with v1 of drawing, or v2, even if it is in which location of a wafer 71v1 or v2, the image of the edge by the scattered light from a wafer mark and a mask mark is vividly detectable. Moreover, since a mask mark also arranges two or more edge patterns in the direction of a x axis and is constituted, even if the location of the direction of the z-axis of a mask shifts, the image of the edge by the scattered light from a mask mark is vividly detectable. In addition, if the pitch of an edge pattern train is chosen so that one of edge patterns may be settled in the depth of focus of a lens, the image of an edge is vividly detectable even if there is no edge on an image formation-ed side exactly.

[0102] Therefore, it is stabilized even if it changes within limits with the fixed location of the direction of the z-axis of a wafer and a mask, and location detection can be performed. Moreover, it can ask for spacing of a wafer and a mask by the same approach as drawing 1 (C) and (D) explained.

[0103] Although this invention was explained in accordance with the example above,

this invention is not restricted to these. For example, probably, it will be obvious to this contractor for various modification, amelioration, combination, etc. to be possible.

[0104]

[Effect of the Invention] As explained above, according to this invention, from the method of slanting, a wafer mark and a mask mark can be observed and location detection can be carried out with high precision. Since it is not necessary to arrange optical system in the exposure range when exposing a wafer after performing alignment, during an exposure period can always perform location detection. For this reason, highly precise exposure is attained.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing and drawing 1 (D) which show the optical intensity distribution within the image according [drawing 1 (C)] to the edge scattered light from a wafer mark and a mask mark and the image surface according [the outline sectional view of the location detection equipment which uses drawing 1 (A) in the example of this invention, and drawing 1 (B)] to the top view of a wafer mark and a mask mark are a sectional view near the image formation-ed side of a wafer side and a mask side.

[Drawing 2] It is the top view and sectional view of a wafer mark which were used for the observation experiment of the edge scattered light.

[Drawing 3] Drawing which sketched the photograph of the image by the edge scattered light from the wafer mark which shows drawing 3 (A) to drawing 2 (B), and drawing 3

(B) are drawings which sketched the photograph of the image which carried out perpendicular detection of the wafer mark shown in drawing 2 (B).

[Drawing 4] It is drawing showing the picture signal of the image by the edge scattered light from the wafer mark shown in drawing 2 (B).

[Drawing 5] It is the graph which shows the result of having carried out signal processing of the picture signal, and having measured the amount of displacement.

[Drawing 6] Drawing where a sectional view [in / in a sectional view / in / in the top view of the alignment mark according / drawing 6 (A) / to the 1st example and drawing 6 (B) / alternate long and short dash line B6-B6 of drawing 6 (A) / and drawing 6 (C) / alternate long and short dash line C6-C6 of drawing 6 (A)] and drawing 6 (D) express the picture signal of the image by the edge scattered light, and drawing 6 (E) are graphs which show the autocorrelation function of the picture signal shown in drawing 6 (D).

[Drawing 7] Drawing where the sectional view of the alignment mark according [drawing 7 (A)] to the 2nd example and drawing 7 (B) express the picture signal of the image by the edge scattered light, and drawing 7 (C) are graphs which show the autocorrelation function of the picture signal shown in drawing 7 (B).

[Drawing 8] The perspective view of one edge pattern with which drawing 8 (A) and (C) constitute a wafer mark, drawing 8 (B), and (D) are drawings showing the image by the edge scattered light from the edge pattern shown in drawing 8 (A) and (C), respectively.

[Drawing 9] The sectional view of the alignment mark according [drawing 9 (A)] to the 3rd example and drawing 9 (B) are drawings showing the picture signal of the image by the edge scattered light.

[Drawing 10] A wafer mark in case the top view of the wafer mark according [drawing 10 (A)] to the 4th example and drawing 10 (B) observe the wafer mark of drawing 10 (A) from across and the outline sectional view of observation optical system, and drawing 10 (C) are the graphs which show the wafer location dependency of the detection location when observing by the approach of showing the wafer mark which shows drawing 10 (A) in drawing 10 (B), and performing location detection of an edge pattern.

[Drawing 11] It is the sectional view of the wafer mark and mask mark by the 4th example.

[Description of Notations]

10 Wafer / Mask Attaching Part

11 Wafer

12 Mask

13 Wafer Mark
14 Mask Mark
15 Wafer Maintenance Base
16 Mask Maintenance Base
17 Drive
20 Optical System
21 Image Detection Equipment
22 Lens
23 Half Mirror
24 Light Source
25 Optical Axis
30 Control Unit
40, 50, 71 Wafer
41, 44, 52A, 52B Wafer mark
42 PSG Film
43 Resist Film
51, 61, 70, 75 Edge pattern
60 74 Mask
62 Mask Mark
72 Image Formation-ed Side
73 Optical Axis